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SITE INVESTIGATION

PROPOSED HOLIDAY PLANTATION
MAKAHA VALLEY, OAHU, HAWAII

FOR

EDWIN YEE & CAPITAL MORTGAGE COMPANY, LTD.

FOR REFERENCE

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June 28, 1972

Joint Venture - Edwin Yee &
Capital Mortgage Company, Ltd.
c/o Lemmon, Freeth, Haines, Jones &
Farrell Architects, Ltd.
165 South King Street
Honolulu, Hawaii 96813

Attention: Mr. Frank Haines, FAIA

Gentlemen:

Transmitted herewith are four copies of our report entitled "Site Investigation, Proposed Holiday Plantation, Makaha Valley, Oahu, Hawaii, for Edwin Yee & Capital Mortgage Company, Ltd."

The investigation was performed in accordance with our proposal dated May 1, 1972. A verbal review of our findings was furnished during a conference on June 22, 1972, attended by representatives of Lemmon, Freeth, Haines, Jones & Farrell, Architects, Ltd.; Sunn, Low, Tom & Hara, Inc., civil engineers; T.Y. Lin, Hawaii, structural engineers; and Dames & Moore.

Subsurface samples obtained during our field exploration which have not been destroyed during laboratory testing are stored in our laboratory for possible future examination. Unless requested otherwise, these samples will be retained for a period of six months from the date of this report.

It has been a pleasure to conduct this investigation on your behalf. If any questions should arise concerning the contents of this report, please contact us for clarification.

Yours very truly,

DAMES & MOORE

Howard Schirmer Jr.
Howard Schirmer, Jr.

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cc: T.Y. Lin, Hawaii Inc.

SITE INVESTIGATION
PROPOSED HOLIDAY PLANTATION
MAKAHA VALLEY, OAHU, HAWAII
FOR

EDWIN YEE & CAPITAL MORTGAGE COMPANY, LTD.

INTRODUCTION

This report presents the results of our site investigation for the proposed Holiday Plantation, Makaha Valley, Oahu, Hawaii. The site is located in Makaha Valley adjacent to the base of the northern mountain ridge. The general location of the site is indicated on the Map of Area, Plate 1. The site is illustrated in detail, including locations of test pits, topography, and surface soils on the Plot Plan and Soils Map, Plate 2.

PROJECT CONSIDERATIONS

The proposed site is located within an area of approximately 41.6 acres. It is anticipated that a total of 850 units in one- to three-story structures will be constructed. Structural loads for all of these facilities are expected to be relatively light. It is anticipated that site grading will be minimal and that consequently cuts, fills, and slopes are to be kept small and will not

exceed a few feet. Access roads servicing the proposed facilities and parking areas are also to be provided and will be private. Some small retaining walls will be constructed adjacent to the parking areas.

SITE CONDITIONS

SOIL HISTORY

All of the soils encountered on the site, with the exception of those materials deposited by man, are alluvial. The numerous basalt cobbles and boulders observed were sub-rounded to rounded, and none exhibited the angularity which is characteristic of talus deposits. Variable rock weathering conditions were observed in the boulders, which extended from highly weathered (almost completely decomposed) to fresh rock. Two major mappable natural soil units were found, which represent different periods of deposition. Predominately grey-brown soils with clay found in the northern site area were originally deposited by ancient river or stream action. A period of erosion then occurred which removed an undetermined amount of this material and left an undulating eroded surface. A new period of deposition then occurred, during which the predominately red-brown soils exhibited in the southern site area were deposited. This material probably at one time covered the entire site, and is therefore generally

underlain by the older grey to brown soils. Later, erosion again occurred, removing an unknown amount of red-brown soils and exposing some of the older grey-brown soils to the north. The last erosional feature formed is the meandering gulley in the southern site area.

SURFACE CONDITIONS

Surface elevations across the site range from +280 to +142 feet with a maximum local relief of approximately 30 feet. The surface material appears stable, and no evidence of recent stream erosion was observed. The steep meandering slope existing in the general southern area is an erosional feature formed by a stream now stabilized south of the proposed site. These exposures exhibit a maximum slope of approximately 1.5 to 1 and are stable. Much of the site has an average slope of approximately 15 to 1 in a southwesterly direction. Vegetation covering the site varies from moderate to quite dense, consisting of high grasses, weeds, and dense trees. The vegetation covers numerous zones of old construction debris. Apparently, the site was at one time cleared and utilized as a construction storage yard.

Surface materials vary from naturally deposited large boulders, cobbles, gravels, and fine silts and clays to man-made granular fills and boulder piles. The natural

materials apparently exert very little control over surface topography. A steep slope near the west central edge of the site has been covered by what appears to be boulder riprap. The northeastern site area contains some piles of stones (helaus) which were apparently placed by the ancient Hawaiians. All man-made deposits are identified as "fill" on the Plot Plan and Soils Map.

The general northern one-half of the site is covered by firm silty sands and clay-silt-sand mixtures. Basalt cobbles and boulders are exposed at intervals on the surface. Occasional cracks in the soil surface were noted, and much of the soil appeared desiccated. Many of the soils included within this zone are expansive. The expansive characteristics noted seem to be generally associated with dark grey to brown clays and clay-silt-sand-gravel mixtures. This material is identified as the "grey to brown" unit on the Soils Map.

The general southern one-half of the site is covered primarily with red to brown silt and sand mixtures with occasional basalt cobbles and boulders. These surface soils are also generally desiccated and are locally moderately expansive in some areas. They are identified as the "red to brown" unit on the Soils Map.

The steep erosional features previously mentioned, which are found in the southern area, exhibit numerous small

to large basalt boulders in a sand and silt matrix and present an exposure of the subsurface materials. These exposures are mapped as a separate unit on the Soils Map.

Three storm drains presently empty onto the site. The approximate locations of the drains are indicated on the Soils Map.

SUBSURFACE CONDITIONS

The older grey to brown soils exposed in the general northern one-half site area continue, in general, to the depths explored by the test pits. These soils consist of clay, silty clay, and clay-silt-sand-gravel mixtures in various proportions, all containing sub-rounded to rounded basalt boulders at frequent intervals. Desiccation extends generally to a depth of one foot. Expansive clays are common in this material, and a clay component in a sandy silt or gravel mixture is sufficient to cause considerable expansion.

The red to brown silt, silty sand, and silt-sand-gravel mixtures with basalt boulders which are exposed in the general southern one-half site area are underlain by the aforementioned grey to brown soil unit. These soils are desiccated near the surface. Several test pits in the southern site area encountered the grey to brown clayey soils at various depths. Some intermixing of these two soil units occurred during deposition of the more recent

material, which resulted in the occasional presence of expansive-type soils in the red to brown material. The red to brown soils exhibit the same irregular basalt boulder concentrations that seem to be typical of the entire site area.

It is possible that small lens deposits of expansive soils may exist between test pits which show no indication of their presence on the ground surface.

Tree roots were encountered in most of the test pits in varying concentrations which were related to vegetation thickness on the surface. Generally, the roots extended to a maximum depth of approximately two feet; however, most were contained within the top one foot of soil. Ground water was not encountered in any of the test pits excavated during this investigation.

A more detailed description of the subsurface materials encountered within the test pits is presented on the Logs of Test Pits, which are included in the attached Appendix.

DISCUSSIONS AND RECOMMENDATIONS

GENERAL

We believe that the site is suitable for construction of the proposed facilities using shallow foundations. However, special precautions will be required during design because of the expansive soils discovered during this investigation.

Many of the soils encountered, especially near the surface, were in a dry, desiccated condition. Normal development procedures will tend to increase the moisture content of these soils by means of landscape watering, revised drainage, increased grassing, and reduction of evaporation by overlying structures. A change of moisture content in an expansive soil will result in a corresponding volume displacement. These anticipated conditions have been given consideration and are included in the following discussions and recommendations.

We believe that a flexible structural building design will provide the most satisfactory performance. Details are included within the following sections.

STRUCTURAL

Design - We recommend that if at all possible, a flexible structural design be incorporated into the proposed buildings. We understand that wood framing

is being considered for structural support and believe this method to be the most suitable of the alternatives available. The presence of moderately thick, highly expansive-type soils leads us to the conclusion that slabs-on-grade are the least desirable alternate. Should slabs-on-grade be used, there is a risk of movement, heaving and cracking, etc.

If however, the utilization of slabs-on-grade is unavoidable, recommendations for construction procedures are included in a following section. Following these recommendations does not eliminate the possibility of cracking over a period of time. Additionally, the application of stucco on exterior surfaces should be avoided as building movements will tend to cause cracks and spalling.

Foundations - We recommend that shallow spread footings be used for foundation support of the proposed buildings. We understand that the footings for all structures will be based upon undisturbed original soils and not upon fill. Footings should be excavated to a depth of at least 2 feet below the adjacent final grade. All footings should possess a minimum width of 18 inches. Footings which are constructed to the aforementioned specifications may utilize an allowable design bearing pressure of 3,000 pounds per square foot.

Slabs-On-Grade - Should the utilization of slabs-on-grade be necessary, we recommend that a minimum of 2 feet of the soils beneath the proposed slabs be excavated and replaced with a mat of compacted granular fill. This mat should be compacted to a minimum of 95 percent of its maximum dry density (AASHO T-180). The mat should be continuously wetted for a period of 48 hours prior to the pouring of concrete. A durable material such as "crusher waste" or "select borrow" should prove acceptable for the construction of the underlying mat. The slabs should be independent of the rest of the structure to allow freedom of movement to reduce cracking. Crack control joints should be used. To prevent moisture infiltration, an impervious vapor barrier should be installed immediately below the floor slab.

Pavement - The following pavement section, which is designed with consideration given to the presence of expansive soils, should provide adequate support for the anticipated traffic loads.

2"	ASPHALTIC CONCRETE
6"	BASE COURSE CBR 8 ⁵ OR GREATER (95 PERCENT COMPACTION BY AASHO T-180)
6"	SUBBASE COURSE CBR OF 25 OR GREATER (95 PERCENT COMPACTION BY AASHO T-180)
6"	RECOMPACTED SUBGRADE (SUITABLE FILL OR EXISTING SOILS SCARIFIED TO A MINIMUM OF 6 INCHES, DELETERIOUS MATERIAL REMOVED AND RECOMPACTED TO 95 PERCENT OF AASHO T-180.)

Following the application of the base course, the area should be continuously sprinkled for a minimum period of 24 hours immediately prior to the application of the pavement section.

The construction of the asphaltic concrete, base course, and subbase course should generally comply respectively with the applicable requirements set forth in Section 34, Section 31 and Section 30 of the Standard Specifications for Public Works Construction prepared by the Department of Public Works, City and County of Honolulu, 1968.

Walkways - Precast concrete walkways may be placed upon a prepared ground surface. If poured-in-place walks are used, frequent crack control joints should be included. The joints must allow independent movement of walkway sections.

Retaining Walls and Swimming Pools - We understand that small retaining walls are being considered for installation adjacent to some of the proposed parking areas. These retaining walls will support the compacted fill to be utilized beneath the parking areas. It is therefore necessary that the retaining walls be designed to withstand the pressures which will be imposed by fill material compacted to 90 percent of the maximum dry density obtainable (AASHTO T-180). It is estimated that the lateral equivalent fluid pressure on these retaining walls will be on the order of 40 pounds per cubic foot plus a vertical surcharge value of 50 pounds per square foot from parked automobiles at the ground surface. The material behind the retaining walls should be well-drained by a gravel blanket immediately behind the wall. Frequent weepholes should be included in the design.

Swimming pool construction should include provision for a thick (approximately 2-foot) gravel blanket surrounding and beneath the pool shell. The gravel blanket will afford protection from expansive soils and tend to restrict cracking.

EARTHWORK

Site Preparation - All vegetation, except trees designated to remain for landscaping purposes, should be thoroughly grubbed and cleared from the site. It is recommended that the grubbing operation be scheduled as close as possible to the beginning of actual construction procedures in order to afford a minimum amount of time for surface erosion to occur. In areas beneath any slabs-on-grade, the ground surface should be scarified to a depth of at least 1 foot below the existing grade to remove roots in excess of $\frac{1}{2}$ inch in diameter. The scarified soil should be recompacted to a dry density of at least 90 percent of the maximum density obtainable by the compaction test method AASHO T-180. Site preparation for pavements is discussed in a previous section.

Excavation - We believe that most excavation operations may be accomplished by use of conventional earth moving equipment. Some problems may be encountered in areas containing very large basalt boulders. Blasting will probably not be required. The sides of shallow excavations should stand on near-vertical slopes for short term periods during construction. Minor sloughing of excavation walls should be anticipated for long-term periods. Surface drainage should be away from the

construction site when excavations are open. Care should be taken during excavation to provide that materials at the supporting elevation of the proposed footings are not over-excavated or disturbed. The exposed materials in excavations for footings should be compacted to at least 90 percent of the material's maximum dry density (AASHTO T-180) prior to the placement of reinforcing steel or concrete. Wetting of the excavations to receive concrete is recommended.

Fill Material - Excavated soils which are free of expansive material, organic debris, cobbles and boulders should prove acceptable as fill. The fill should not contain particles greater than 6 inches in any dimension.

Fill Construction - Fill should be placed in lifts, the thickness of which would depend on the effectiveness of the compacting procedures. We believe that on-site soils which are to be used for fill will respond best to compaction by sheepfoot rollers. Portable impact compactors may be used in areas which may be inaccessible to large compaction equipment. Each lift of fill should be moistened, if required, and compacted to a minimum of 90 percent of the material's maximum dry density (AASHTO T-180).

Slopes - The steep erosional slopes in the southern one-half of the site reach a maximum value of 1.5 to 1. The slopes appear stable; however, some sloughing or erosion may occur, especially during periods of unusually high rainfall. It is recommended that vegetation be maintained in these areas to afford some degree of erosion control. It is further recommended that structures near the top of the slopes be located a minimum distance of 10 feet from the slope's upper edge so that foundations are not affected by erosion.

Heiaus - All possible heiaus on the site should be located and evaluated to determine their authenticity. Should these features prove to be of archeological value, they could be incorporated into the overall site plan, if desired, providing areas of historical interest.

INSPECTION

Recommendations presented within this report are based on the soil conditions encountered in the test pits excavated during this investigation. Should soil conditions other than those discussed in this report be encountered during construction, we should receive immediate notification in order that appropriate construction modifications may be implemented, if necessary. Due to the variable subsurface conditions observed, we recommend that all foundation excavations be inspected and

approved by a soils engineer prior to placement of steel or concrete. This will assure that the subsoil conditions are of comparable competency with those encountered during this investigation. We recommend that fill and backfill placement, including construction of recompacted subgrade, subbase, and base course for pavements also be inspected and approved by a soils engineer. Additionally, we suggest that grading plans and specifications be reviewed to determine if they are in accord with the intent of the recommendations provided.

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The following Plates and Appendix are attached and complete this report.

Plate 1	-	Map of Area
Plate 2	-	Plot Plan and Soils Map
Appendix	-	Field Exploration and Laboratory Testing

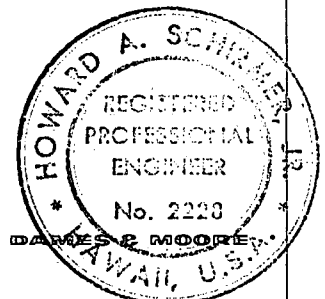
Respectfully submitted,

DAMES & MOORE

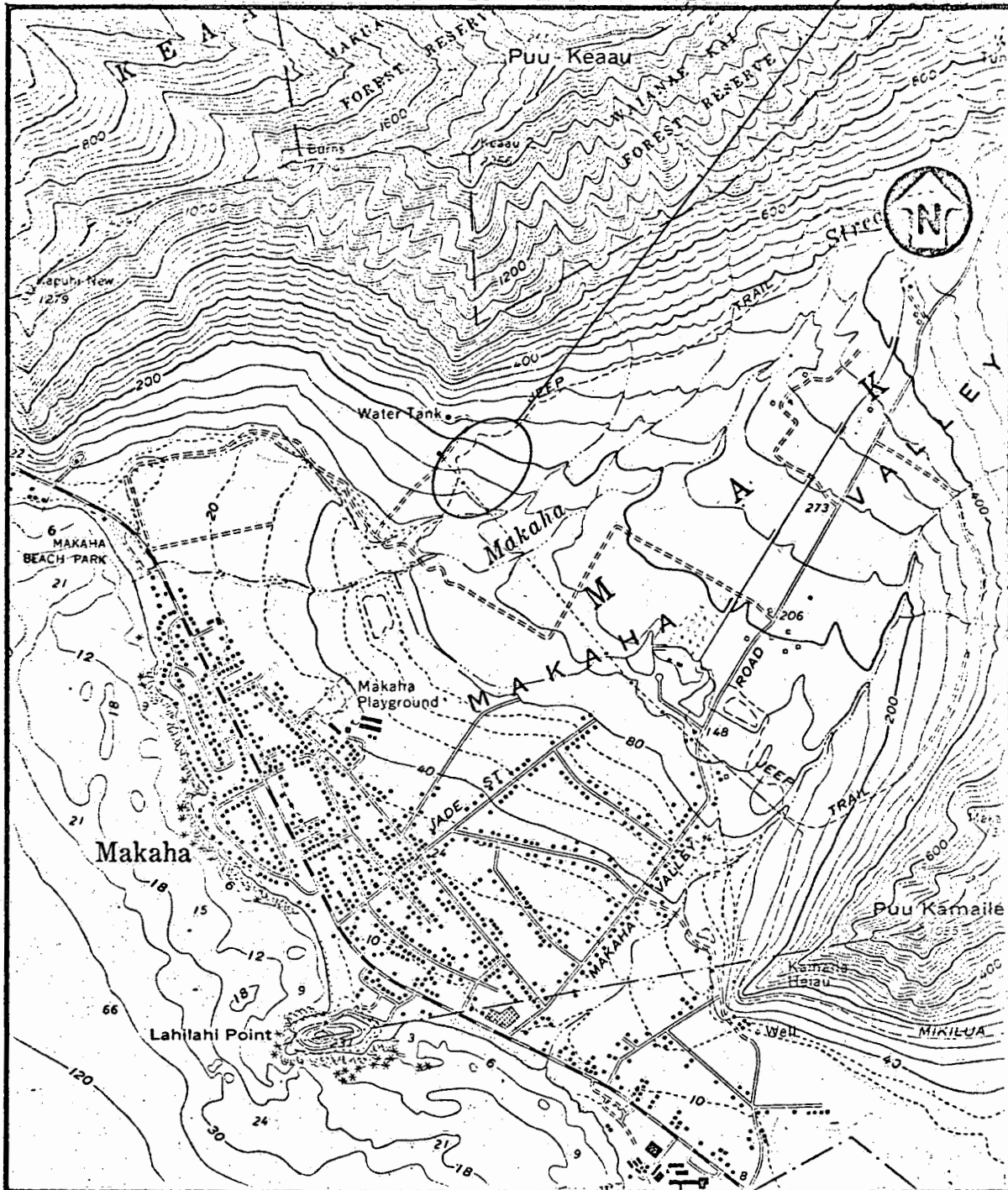
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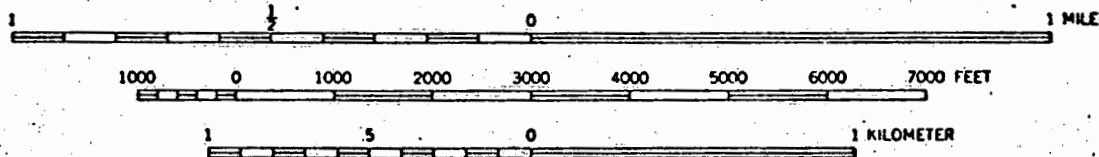


GENERAL AREA OF SITE AS SHOWN ON PLOT PLAN AND SOILS MAP



MAP OF AREA

SCALE 1:24000



REFERENCE:
U.S.G.S. QUADRANGLE MAP
WAIANAE, HAWAII
DATED 1963

DAMES & MOORE

944.7 (REV. 6-61)
BY DATE 0-26-72
CHECKED BY WBS
FILE 9647-001
REVISIONS
BY DATE

APPENDIX

FIELD EXPLORATION AND LABORATORY TESTING

FIELD EXPLORATION

The subsurface conditions at the site were explored by excavating 24 test pits ranging in depth from 1.0 feet to 11.8 feet. Proposed Test Pit 23 was not accessible to the backhoe and was not excavated. The depth of excavation of the test pits was determined by the concentration and size of basalt boulders. All test pits were excavated with a backhoe furnished by a subcontractor. Access to test pit locations required the clearing of brush and trees by a bulldozer which was also furnished by a subcontractor. Relatively undisturbed and disturbed samples of the subsoils encountered were recovered using the Dames & Moore Type D sampler, depicted on Exhibit A-1.

All test pits were excavated under the technical direction of our engineering geologist who obtained samples of the subsoils at the site. Our geologist also maintained a continuous detailed log of each test pit with pertinent descriptions of soils found within each excavation; the logs of the test pits are presented on Plates A-1A through A-1F. Subsurface materials recovered from the test pits were classified according to the Unified Soil Classification System presented on Plate A-2.

During the field exploration, our representative examined the various materials exposed on the surface of the site and constructed a surface soils map. This information is presented on the Plot Plan and Soils Map, Plate 2.

LABORATORY TESTING

Selected samples of the subsurface materials obtained during the field exploration were subjected to various laboratory tests in order to evaluate their physical properties. A description of the tests and the test results are presented in the following paragraphs.

Compaction Tests - Two compaction tests were conducted on bulk samples of the materials recovered from Test Pits 4 and 17. The tests were conducted in accordance with AASHTO Designation T-180 procedures. A description of the procedure used is presented on Exhibit A-2, and the results of these tests are presented on Plates A-3 and A-4, Compaction Test Data.

California Bearing Ratio Tests - Two California bearing ratio (CBR) tests were conducted on recompacted samples of the soils recovered from Test Pits 4 and 17 to assist in obtaining information pertinent to flexible

pavement design. The results of these tests are tabulated below.

	<u>TP-4</u>	<u>TP-17</u>
Dry Density in PCF	94.0	96.0
Percent Compaction	95.0	89.0
Surcharge in Pounds	10.0	10.0
Swell in Percent	0.0	0.1
CBR at 0.1-inch Penetration	1.0	2.2
CBR at 0.2-inch Penetration	1.0	2.8
Moisture Content in Percent	28.3	27.7

Direct Shear Tests - Selected samples were subjected to direct shear tests in order to evaluate their shear strength characteristics. These tests were conducted according to the procedure described on Exhibit A-3, Method of Performing Direct Shear and Friction Tests. The results of these tests are presented below.

<u>Test Pit No.</u>	<u>Depth (ft)</u>	<u>Normal Pressure (psf)</u>	<u>Peak Shear Strength (psf)</u>
1	11.5	800	1190
3	1.3	200	640
8	3.4	2000	1900
9	1.6	200	2000
10	5.3	500	1300
11	2.0	2000	3700
12	4.3	2000	1900
13	3.0	300	960
13	3.0	1000	1590
15	4.4	500	810
21	1.5	300	1280
21	1.5	1000	2100

Expansion Tests - Expansion tests were conducted on various samples in order to determine expansion characteristics of the soils present on the site. The following test results were obtained under a surcharge of 100 pounds per square foot.

Test Pit No.	Depth (ft)	Dry Density (pcf)			Expansion (%)
		(natural)	(air- dried)	(after saturation)	
3	3.6	75.7	105.9	81.5	32.9
3	5.7	72.9	72.9	73.5	-0.8 (consol)
6	1.6	76.4	89.2	72.3	33.0
12	2.5	60.7	63.5	66.0	-3.8 (consol)
13	1.7	93.2	93.1	85.1	9.5
17	1.8	76.9	76.7	77.1	-0.1 (consol)
18	3.8	75.5	75.5	77.2	-2.3 (consol)
22	6.0	87.0	87.0	85.1	2.1
24	1.5	65.5	--	78.1	-3.6 (consol)
25	1.4	65.0	--	66.5	-2.4 (consol)

A graphic representation of these data is presented on Soil Expansion Characteristics, Plate A-5.

Atterberg Limits Tests - Atterberg limits tests were performed on selected samples to provide data for engineering analyses and identification. The results of these tests follow:

<u>Test Pit No.</u>	<u>Depth (ft)</u>	<u>Liquid Limit (%)</u>	<u>Plastic Limit (%)</u>	<u>Plasticity Index (%)</u>	<u>Identification</u>
3	3.6	102	37	65	CH
3	5.7	57	38	19	MH
6	1.6	104	31	73	CH
12	2.5	44	30	14	ML
13	1.7	72	26	46	CH
17	1.8	42	29	13	ML
18	3.8	53	29	24	MH/CH
22	6.0	59	30	29	CH/MH
24	1.5	45	28	17	ML
25	1.4	45	29	16	ML

The liquid limit parameter, determined during Atterberg Limits testing, provides an indication of the expansive characteristics of a particular soil sample. This relationship has been developed for the site and is presented on the Soil Expansion vs Liquid Limit Graph, Plate A-6.

Mechanical Analyses - Mechanical analyses were conducted on one sample in order to determine gradation characteristics. The results of this test are presented on Plate A-7, Gradation Curve.

- A-6 -

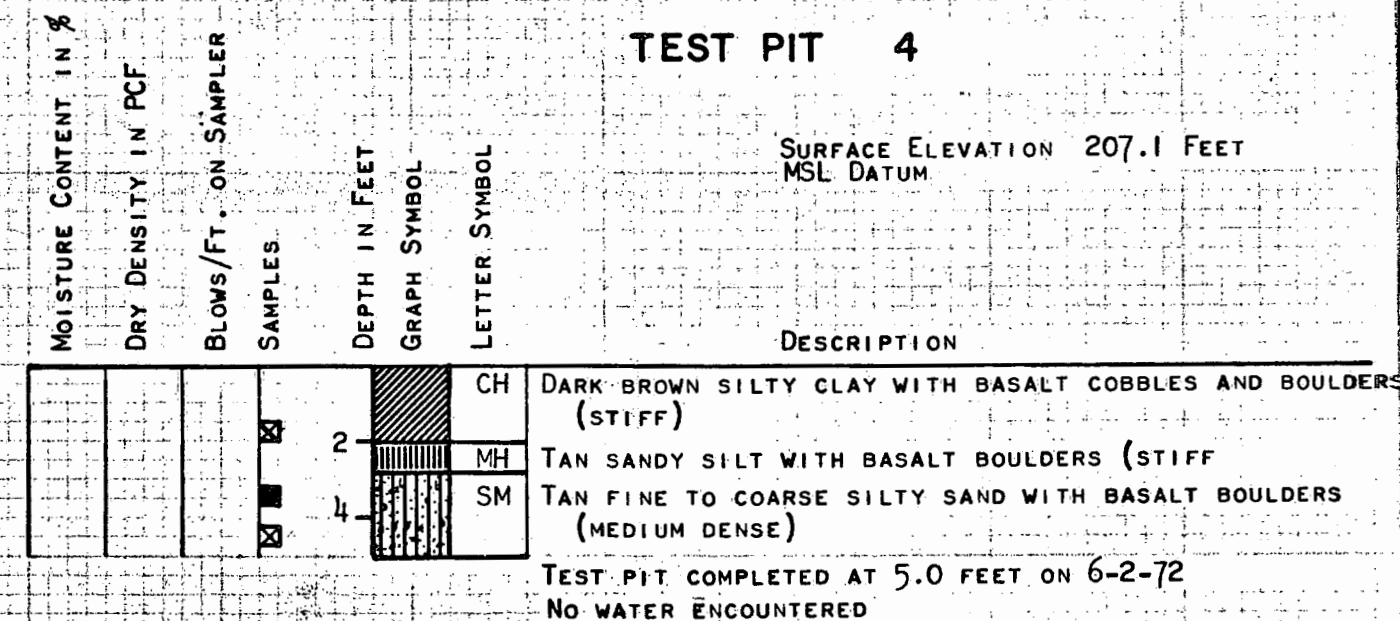
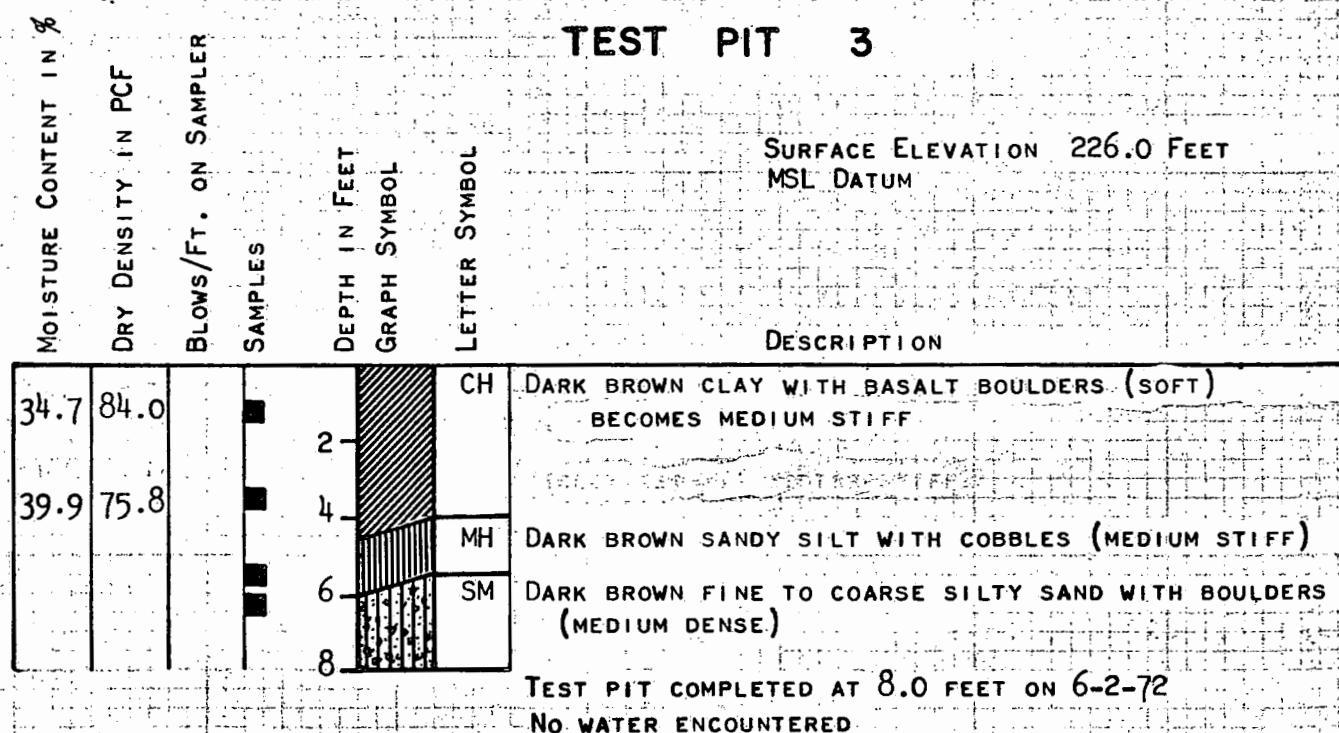
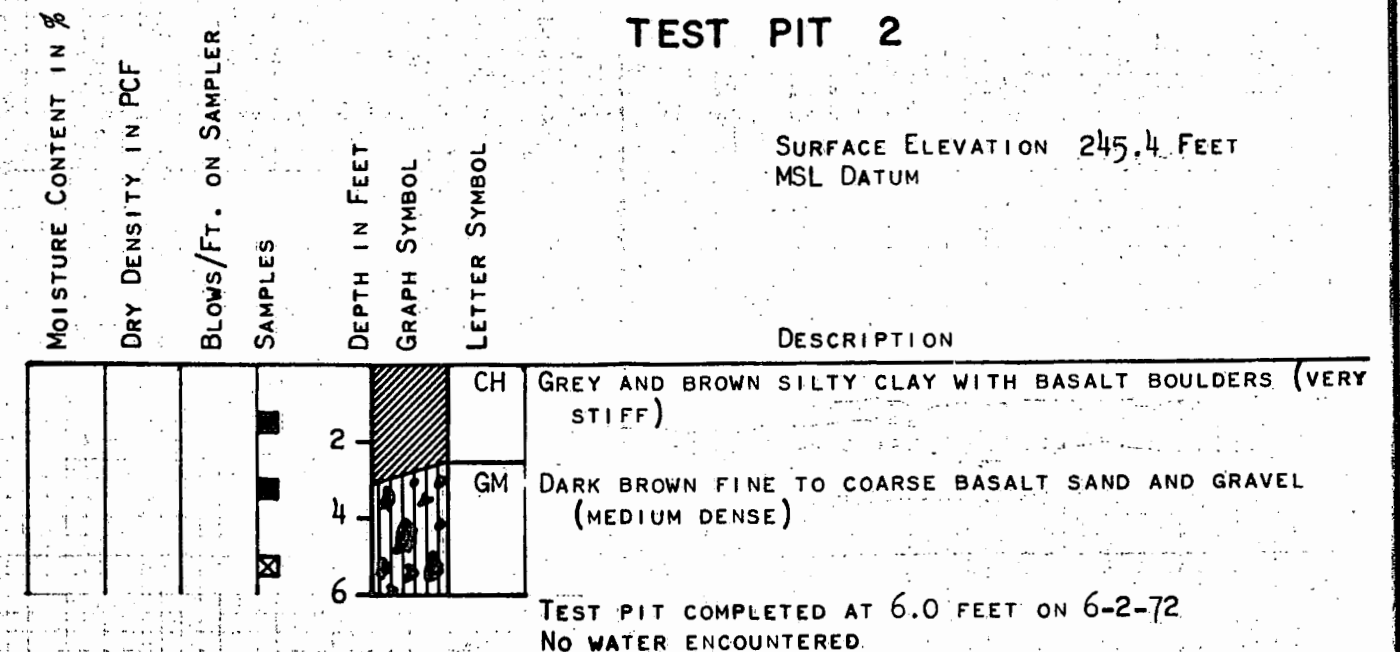
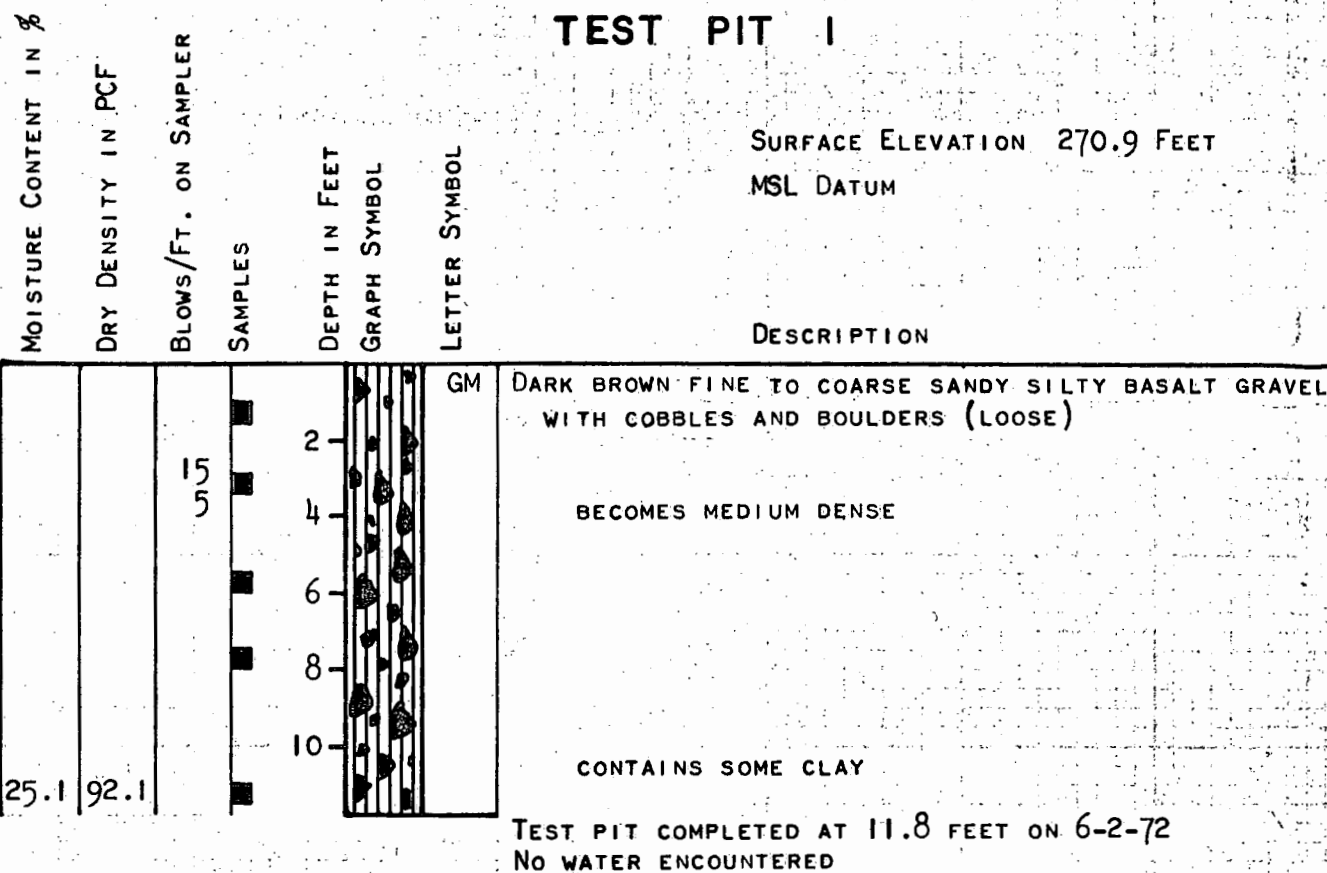
Moisture Content and Dry Density Determinations -

Numerous samples were subjected to moisture content and dry density determinations to provide data for classification and engineering analyses. The results of these tests are presented on the Log of Test Pits at the appropriate sample depth.

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The following Plates and Exhibits are attached and complete this Appendix.

- Plate A-1A Log of Test Pits,
 Test Pits 1 through 4
- Plate A-1B - Log of Test Pits,
 Test Pits 5 through 8
- Plate A-1C - Log of Test Pits,
 Test Pits 9 through 12
- Plate A-1D - Log of Test Pits,
 Test Pits 13 through 16
- Plate A-1E - Log of Test Pits,
 Test Pits 17 through 20
- Plate A-1F - Log of Test Pits,
 Test Pits 21, 22, 24 and 25
- Plate A-2 - Unified Soil Classification
 System
- Plate A-3 - Compaction Test Data,
 TP-4
- Plate A-4 - Compaction Test Data,
 TP-17
- Plate A-5 - Soil Expansion Characteristics
- Plate A-6 - Soil Expansion vs
 Liquid Limit
- Plate A-7 - Gradation Curve
- Exhibit A-1 - Soil Sampler Type D
- Exhibit A-2 - Method of Performing Compaction
 Tests
- Exhibit A-3 - Method of Performing Direct
 Shear and Friction Tests



NOTES:

- - DEPTH AT WHICH UNDISTURBED SAMPLE WAS TAKEN
- ⊠ - DEPTH AT WHICH DISTURBED SAMPLE WAS TAKEN
- - DEPTH AT WHICH SAMPLE WAS LOST DURING EXTRACTION

DRIVING ENERGY - 40 LB. HAMMER DROPPING 18 INCHES WHERE BLOW COUNT DATA IS INCLUDED; OTHERWISE SAMPLER DRIVEN BY BACKHOE.

LOG OF TEST PITS

TEST PIT 9

SURFACE ELEVATION 234.0 FEET
MSL DATUM

MOISTURE CONTENT IN %	DRY DENSITY IN PCF	BLOWS/FT. ON SAMPLER	DEPTH IN FEET	GRAPH SYMBOL	LETTER SYMBOL	DESCRIPTION
23.2	72.4		2	ML	ML	DARK BROWN CLAYEY SILT WITH BASALT GRAVEL (STIFF)
			4	GM	GM	BROWN SANDY GRAVEL (MEDIUM DENSE)
			6	SM	SM	DARK BROWN FINE TO COARSE SILTY SAND WITH BASALT GRAVEL (MEDIUM DENSE)

TEST PIT COMPLETED AT 7.1 FEET ON 6-5-72
NO WATER ENCOUNTERED

TEST PIT 11

SURFACE ELEVATION 200.0 FEET
MSL DATUM

MOISTURE CONTENT IN %	DRY DENSITY IN PCF	BLOWS/FT. ON SAMPLER	DEPTH IN FEET	GRAPH SYMBOL	LETTER SYMBOL	DESCRIPTION
24.7	72.7	15	2	CH	CH	DARK BROWN SILTY CLAY WITH BASALT BOULDERS (MEDIUM STIFF)
			4	ML	ML	GREY SANDY SILTY GRAVEL (MEDIUM DENSE)
22.7	66.7		6			

TEST PIT COMPLETED AT 6.5 FEET ON 6-5-72
NO WATER ENCOUNTERED

TEST PIT 10

SURFACE ELEVATION 217.6 FEET
MSL DATUM

MOISTURE CONTENT IN %	DRY DENSITY IN PCF	BLOWS/FT. ON SAMPLER	DEPTH IN FEET	GRAPH SYMBOL	LETTER SYMBOL	DESCRIPTION
15.4	89.7		2	GM	GM	DARK BROWN SILTY SANDY BASALT GRAVEL WITH BASALT BOULDERS (MEDIUM DENSE)
			4	SM	SM	INCREASING SAND CONTENT GREY-BROWN FINE TO COARSE SILTY SAND (MEDIUM DENSE)

TEST PIT COMPLETED AT 7.0 FEET ON 6-5-72
NO WATER ENCOUNTERED

TEST PIT 12

SURFACE ELEVATION 186.8 FEET
MSL DATUM

MOISTURE CONTENT IN %	DRY DENSITY IN PCF	BLOWS/FT. ON SAMPLER	DEPTH IN FEET	GRAPH SYMBOL	LETTER SYMBOL	DESCRIPTION
14.6	73.7	65	2	ML	ML	RED-BROWN SANDY GRAVELLY SILT WITH BOULDERS (MEDIUM STIFF)
78.8	67.0		4			GRADING TO SANDY SILT
23.1	57.8		6	CH	CH	DARK GREY SILTY CLAY (MEDIUM STIFF)
29.7	89.8					

TEST PIT COMPLETED AT 6.0 FEET ON 6-5-72
NO WATER ENCOUNTERED

LOG OF TEST PITS

NOTES:

- - DEPTH AT WHICH UNDISTURBED SAMPLE WAS TAKEN
 - ⊗ - DEPTH AT WHICH DISTURBED SAMPLE WAS TAKEN
 - - DEPTH AT WHICH SAMPLE WAS LOST DURING EXTRACTION
- DRIVING ENERGY - 40 LB. HAMMER DROPPING 18 INCHES WHERE BLOW COUNT DATA IS INCLUDED; OTHERWISE SAMPLER DRIVEN BY BACKHOE.

TEST PIT 13

SURFACE ELEVATION 179.4 FEET
MSL DATUM

MOISTURE CONTENT IN %	DRY DENSITY IN PCF	BLOWS/FT. ON SAMPLER	SAMPLES	DEPTH IN FEET	GRAPH SYMBOL	LETTER SYMBOL	DESCRIPTION
27.6	75.8		■	2	CH	CH	DARK GREY-BROWN SILTY CLAY (VERY STIFF)
			■		SM	SM	DARK GREY SILTY SAND WITH BASALT GRAVEL (MEDIUM DENSE)
TEST PIT COMPLETED AT 3.0 FEET ON 6-6-72 NO WATER ENCOUNTERED							

TEST PIT 14

SURFACE ELEVATION 166.3 FEET
MSL DATUM

MOISTURE CONTENT IN %	DRY DENSITY IN PCF	BLOWS/FT. ON SAMPLER	SAMPLES	DEPTH IN FEET	GRAPH SYMBOL	LETTER SYMBOL	DESCRIPTION
			■	2	ML-SM	ML-SM	RED BROWN SILT AND SILTY SAND WITH BASALT GRAVEL (VERY STIFF AND DENSE)
			■		GM	GM	BROWN SILTY SANDY BASALT GRAVEL (DENSE)
			■		SM	SM	BROWN-GREY SILTY SAND (MEDIUM DENSE)
TEST PIT COMPLETED AT 3.8 FEET ON 6-6-72 NO WATER ENCOUNTERED							

TEST PIT 15

SURFACE ELEVATION 240.0 FEET
MSL DATUM

MOISTURE CONTENT IN %	DRY DENSITY IN PCF	BLOWS/FT. ON SAMPLER	SAMPLES	DEPTH IN FEET	GRAPH SYMBOL	LETTER SYMBOL	DESCRIPTION
15.8	71.2		■	2	ML	ML	RED BROWN GRAVELLY SILT (MEDIUM DENSE)
			■	4	SM	SM	BROWN FINE TO COARSE SILTY GRAVELLY SAND (MEDIUM DENSE)
TEST PIT COMPLETED AT 4.7 FEET ON 6-7-72 NO WATER ENCOUNTERED							

TEST PIT 16

SURFACE ELEVATION 212.3 FEET
MSL DATUM

MOISTURE CONTENT IN %	DRY DENSITY IN PCF	BLOWS/FT. ON SAMPLER	SAMPLES	DEPTH IN FEET	GRAPH SYMBOL	LETTER SYMBOL	DESCRIPTION
			■	2	GM	GM	RED-BROWN SANDY GRAVEL (MEDIUM DENSE)
			■		GM-GC	GM-GC	RED-BROWN AND GREY SILTY AND CLAYEY GRAVEL WITH BASALT BOULDERS (MEDIUM DENSE)
TEST PIT COMPLETED AT 3.0 FEET ON 6-6-72 NO WATER ENCOUNTERED							

LOG OF TEST PITS

NOTES:

- - DEPTH AT WHICH UNDISTURBED SAMPLE WAS TAKEN
 - ⊠ - DEPTH AT WHICH DISTURBED SAMPLE WAS TAKEN
 - - DEPTH AT WHICH SAMPLE WAS LOST DURING EXTRACTION
- DRIVING ENERGY - 40 LB. HAMMER DROPPING 18 INCHES WHERE BLOW COUNT DATA IS INCLUDED; OTHERWISE SAMPLER DRIVEN BY BACKHOE.

TEST PIT 17

SURFACE ELEVATION 217.6 FEET
MSL DATUM

DESCRIPTION

MOISTURE CONTENT IN %	DRY DENSITY IN PCF	BLOWS/FT. ON SAMPLER	SAMPLES	DEPTH IN FEET	GRAPH SYMBOL	LETTER SYMBOL	DESCRIPTION
17.7	83.3		<input checked="" type="checkbox"/>	2	ML	ML	RED BROWN SILT (MEDIUM STIFF)
20.8	81.7		<input checked="" type="checkbox"/>	4	GM	GM	RED BROWN SILTY BASALT GRAVEL (MEDIUM DENSE)
			<input checked="" type="checkbox"/>	6	GM	GM	BROWN SANDY GRAVEL (MEDIUM DENSE)
TEST PIT COMPLETED AT 5.0 FEET ON 6-6-72							
NO WATER ENCOUNTERED							

TEST PIT 18

SURFACE ELEVATION 201.5 FEET
MSL DATUM

DESCRIPTION

MOISTURE CONTENT IN %	DRY DENSITY IN PCF	BLOWS/FT. ON SAMPLER	SAMPLES	DEPTH IN FEET	GRAPH SYMBOL	LETTER SYMBOL	DESCRIPTION
21.3	82.3		<input checked="" type="checkbox"/>	2	MH	MH	RED SILT (MEDIUM STIFF)
22.9	83.7		<input checked="" type="checkbox"/>	4	MH-CH	MH-CH	DARK BROWN CLAYEY SILT AND SILTY CLAY (VERY STIFF)
			<input checked="" type="checkbox"/>	6	CH	CH	DARK GREY SANDY GRAVELLY CLAY (STIFF)
			<input checked="" type="checkbox"/>	6	SM	SM	DARK BROWN SILTY SAND (MEDIUM DENSE)
TEST PIT COMPLETED AT 6.0 FEET ON 6-6-72							
NO WATER ENCOUNTERED							

TEST PIT 19

SURFACE ELEVATION 187.0 FEET
MSL DATUM

DESCRIPTION

MOISTURE CONTENT IN %	DRY DENSITY IN PCF	BLOWS/FT. ON SAMPLER	SAMPLES	DEPTH IN FEET	GRAPH SYMBOL	LETTER SYMBOL	DESCRIPTION
			<input checked="" type="checkbox"/>	2	ML	ML	RED SANDY SILT WITH BASALT BOULDERS (LOOSE)
			<input checked="" type="checkbox"/>	4	CL	CL	GREY SILTY CLAY (VERY STIFF)
			<input checked="" type="checkbox"/>	6	GM	GM	BROWN SANDY GRAVEL (DENSE)
TEST PIT COMPLETED AT 3.5 FEET ON 6-6-72							
NO WATER ENCOUNTERED							

TEST PIT 20

SURFACE ELEVATION 164.2 FEET
MSL DATUM

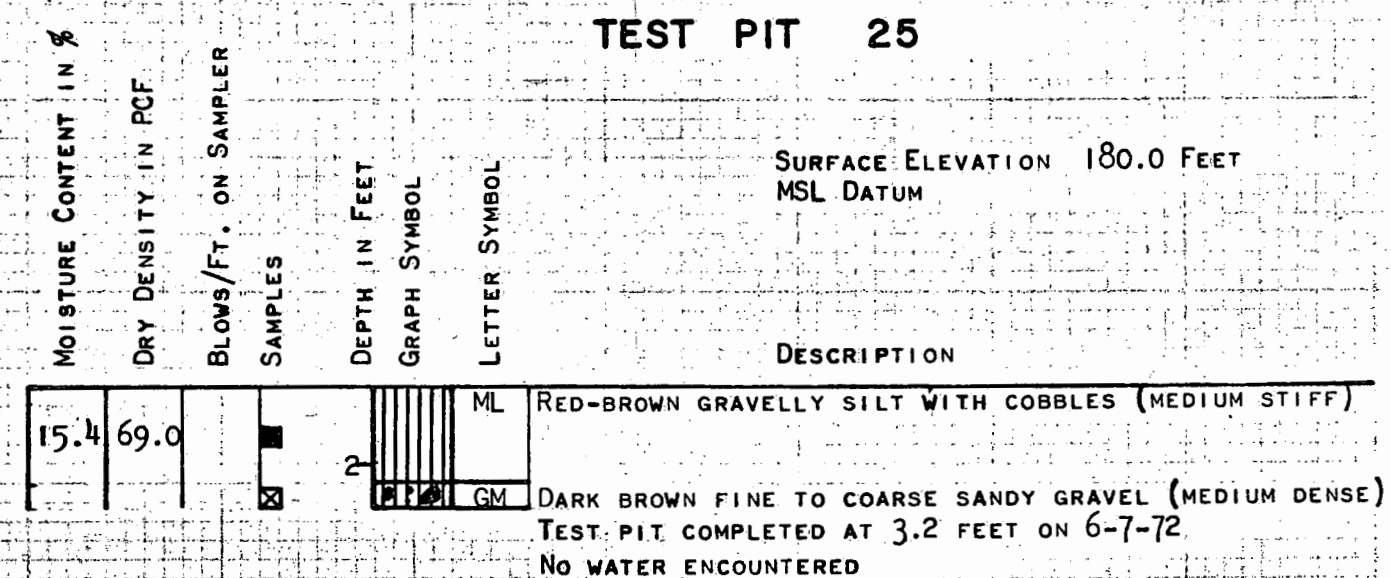
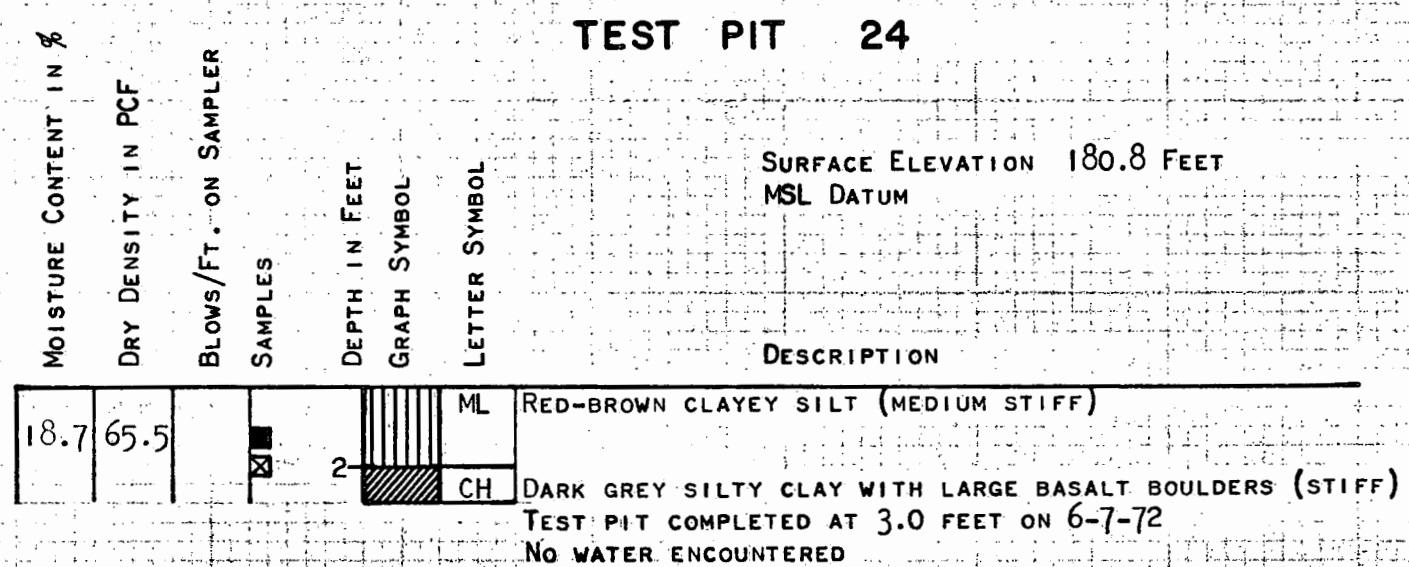
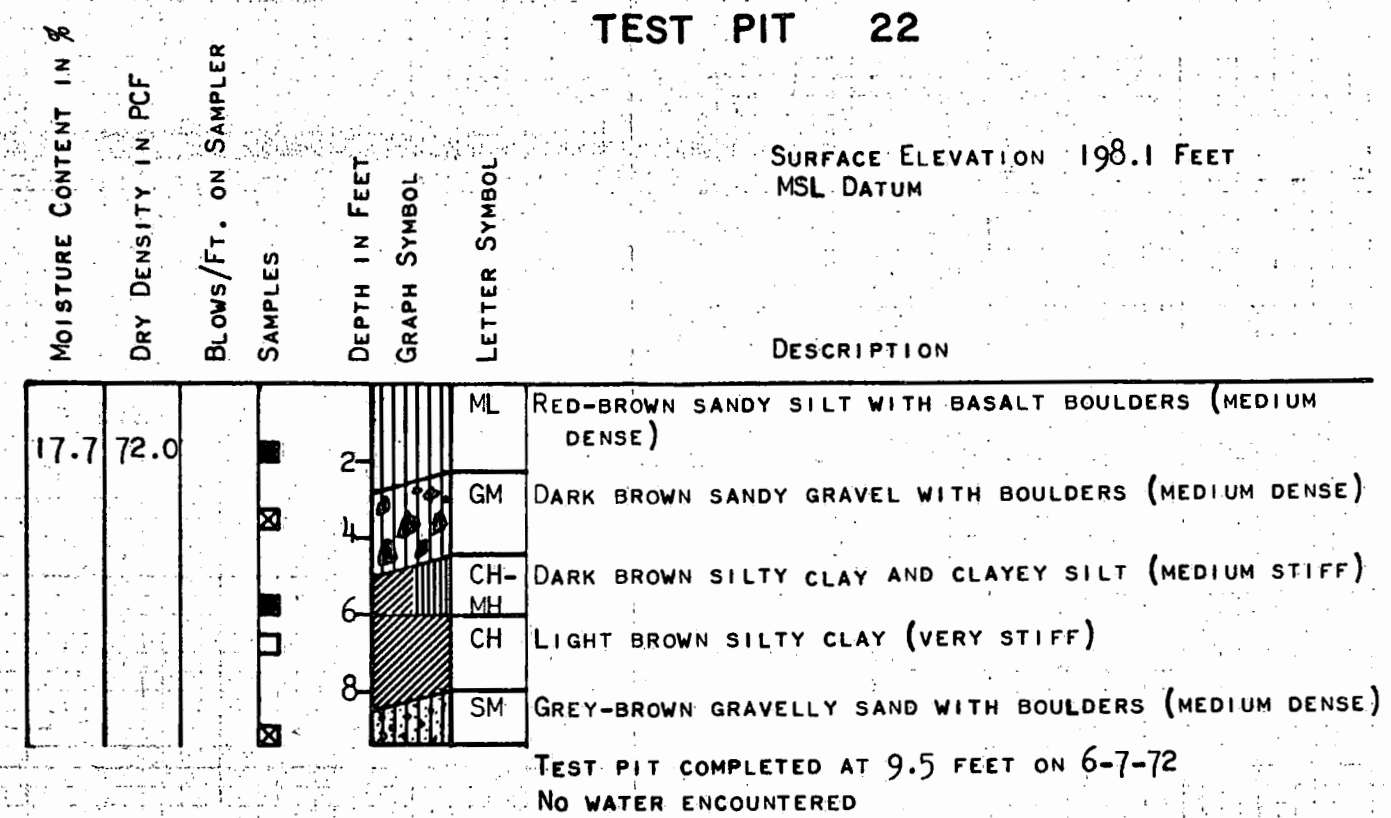
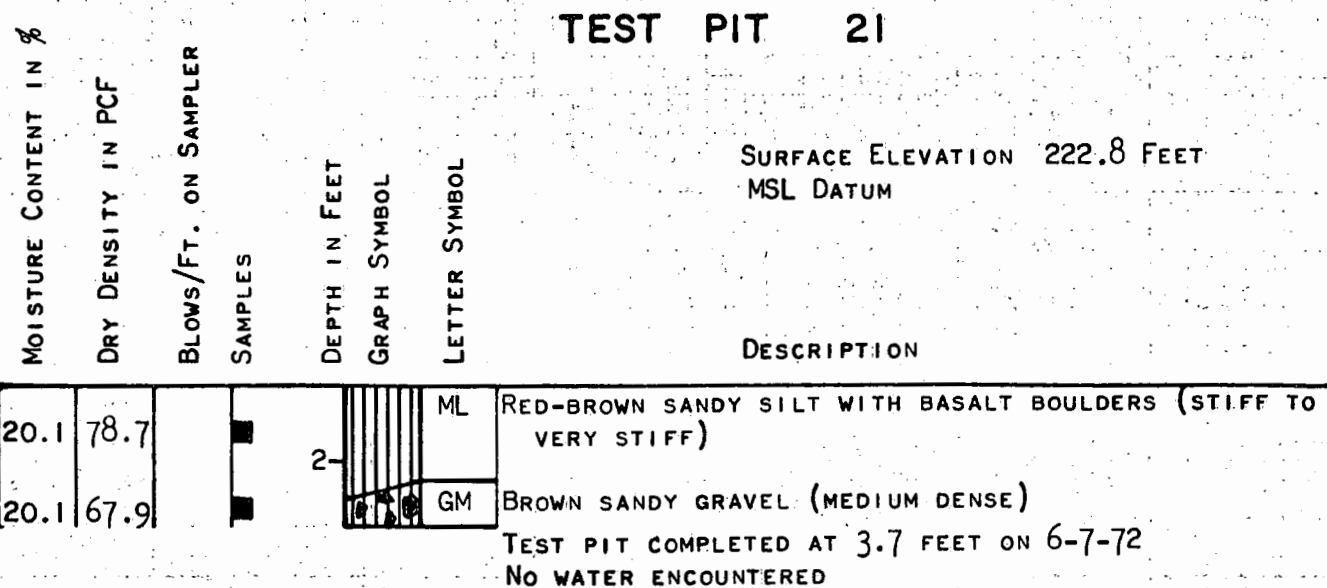
DESCRIPTION

MOISTURE CONTENT IN %	DRY DENSITY IN PCF	BLOWS/FT. ON SAMPLER	SAMPLES	DEPTH IN FEET	GRAPH SYMBOL	LETTER SYMBOL	DESCRIPTION
			<input checked="" type="checkbox"/>	2	GM	GM	RED-BROWN SANDY BASALT GRAVEL WITH BASALT BOULDERS (MEDIUM DENSE)
26.3	95.5		<input checked="" type="checkbox"/>	4	MH	MH	DARK GREY SILT (VERY STIFF)
TEST PIT COMPLETED AT 5.2 FEET ON 6-6-72							
NO WATER ENCOUNTERED							

LOG OF TEST PITS

NOTES:

- ☒ - DEPTH AT WHICH UNDISTURBED SAMPLE WAS TAKEN
 - ☒ - DEPTH AT WHICH DISTURBED SAMPLE WAS TAKEN
 - ☐ - DEPTH AT WHICH SAMPLE WAS LOST DURING EXTRACTION
- DRIVING ENERGY - 40 LB. HAMMER DROPPING 18 INCHES WHERE BLOW COUNT DATA IS INCLUDED; OTHERWISE SAMPLER DRIVEN BY BACKHOE.

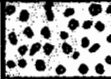
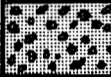


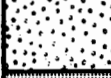









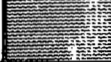


LOG OF TEST PITS

NOTES:

- - DEPTH AT WHICH UNDISTURBED SAMPLE WAS TAKEN
 - ⊠ - DEPTH AT WHICH DISTURBED SAMPLE WAS TAKEN
 - - DEPTH AT WHICH SAMPLE WAS LOST DURING EXTRACTION
- DRIVING ENERGY - 40 LB. HAMMER DROPPING 18 INCHES WHERE BLOW COUNT DATA IS INCLUDED; OTHERWISE SAMPLER DRIVEN BY BACKHOE.

SOIL CLASSIFICATION CHART

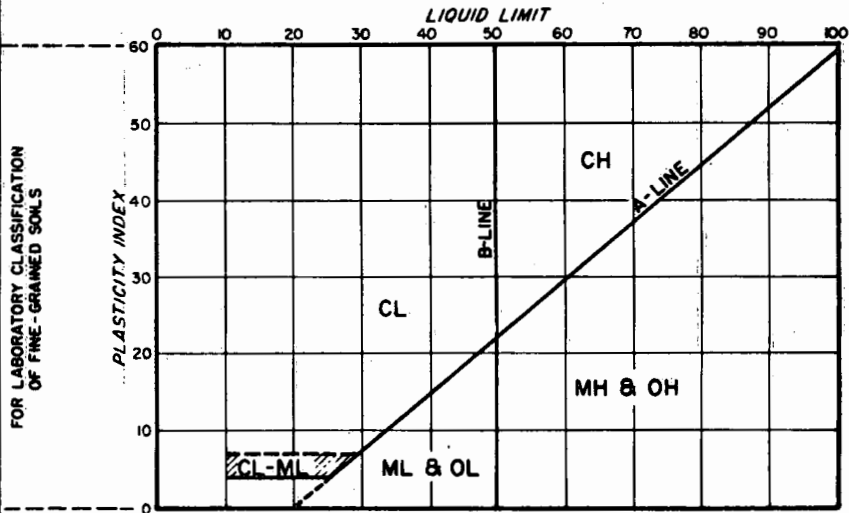
MAJOR DIVISIONS			GRAPH SYMBOL	LETTER SYMBOL	TYPICAL DESCRIPTIONS		
COARSE GRAINED SOILS MORE THAN 50 % OF MATERIAL IS LARGER THAN NO. 200 SIEVE SIZE	GRAVEL AND GRAVELLY SOILS MORE THAN 50 % OF COARSE FRACTION <u>RETAINED</u> ON NO. 4 SIEVE	CLEAN GRAVELS (LITTLE OR NO FINES)		GW	WELL-GRADED GRAVELS, GRAVEL-SAND MIXTURES, LITTLE OR NO FINES		
				GP	POORLY-GRADED GRAVELS, GRAVEL-SAND MIXTURES, LITTLE OR NO FINES		
		GRAVELS WITH FINES (APPRECIABLE AMOUNT OF FINES)		GM	SILTY GRAVELS, GRAVEL-SAND-SILT MIXTURES		
				GC	CLAYEY GRAVELS, GRAVEL-SAND-CLAY MIXTURES		
	SAND AND SANDY SOILS MORE THAN 50 % OF MATERIAL IS LARGER THAN NO. 200 SIEVE SIZE	CLEAN SAND (LITTLE OR NO FINES)		SW	WELL-GRADED SANDS, GRAVELLY SANDS, LITTLE OR NO FINES		
				SP	POORLY-GRADED SANDS, GRAVELLY SANDS, LITTLE OR NO FINES		
		SANDS WITH FINES (APPRECIABLE AMOUNT OF FINES)		SM	SILTY SANDS, SAND-SILT MIXTURES		
				SC	CLAYEY SANDS, SAND-CLAY MIXTURES		
FINE GRAINED SOILS MORE THAN 50 % OF MATERIAL IS SMALLER THAN NO. 200 SIEVE SIZE	SILTS AND CLAYS LIQUID LIMIT <u>LESS</u> THAN 50		ML	INORGANIC SILTS AND VERY FINE SANDS, ROCK FLOUR, SILTY OR CLAYEY FINE SANDS OR CLAYEY SILTS WITH SLIGHT PLASTICITY			
				CL	INORGANIC CLAYS OF LOW TO MEDIUM PLASTICITY, GRAVELLY CLAYS, SANDY CLAYS, SILTY CLAYS, LEAN CLAYS		
				OL	ORGANIC SILTS AND ORGANIC SILTY CLAYS OF LOW PLASTICITY		
	SILTS AND CLAYS LIQUID LIMIT <u>GREATER</u> THAN 50		MH	INORGANIC SILTS, MICACEOUS OR DIATOMACEOUS FINE SAND OR SILTY SOILS			
				CH	INORGANIC CLAYS OF HIGH PLASTICITY, FAT CLAYS		
				OH	ORGANIC CLAYS OF MEDIUM TO HIGH PLASTICITY, ORGANIC SILTS		
			HIGHLY ORGANIC SOILS			PT	PEAT, HUMUS, SWAMP SOILS WITH HIGH ORGANIC CONTENTS

GRADATION CHART

MATERIAL SIZE		PARTICLE SIZE			
		LOWER LIMIT		UPPER LIMIT	
		MILLIMETERS	SIEVE SIZE*	MILLIMETERS	SIEVE SIZE*
SAND	FINE	.075	#200*	0.425	#40*
	MEDIUM	0.425	#40*	2.00	#10*
	COARSE	2.00	#10*	4.75	#4*
GRAVEL	FINE	4.75	#4*	19.0	3/4"*
	COARSE	19.0	3/4"*	76.2	3"*
COBBLES		76.2	3"*	304.8	12"*
BOULDERS		304.8	12"*	914.4	36"*

* U.S. STANDARD * CLEAR SQUARE OPENINGS

PLASTICITY CHART



- NOTES:
- DUAL SYMBOLS ARE USED TO INDICATE BORDERLINE CLASSIFICATIONS.
 - WHEN SHOWN ON THE BORING LOGS, THE FOLLOWING TERMS ARE USED TO DESCRIBE THE CONSISTENCY OF COHESIVE SOILS AND THE RELATIVE COMPACTNESS OF COHESIONLESS SOILS.

COHESIVE SOILS		COHESIONLESS SOILS	
(APPROXIMATE SHEARING STRENGTH IN KSF)			
VERY SOFT	LESS THAN .25	VERY LOOSE	THESE ARE USUALLY BASED ON AN EXAMINATION OF SOIL SAMPLES, PENETRATION RESISTANCE, AND SOIL DENSITY DATA.
SOFT	0.25 TO 0.5	LOOSE	
MEDIUM STIFF	0.5 TO 1.0	MEDIUM DENSE	
STIFF	1.0 TO 2.0	DENSE	
VERY STIFF	2.0 TO 4.0	VERY DENSE	
HARD	GREATER THAN 4.0		

SAMPLES

- INDICATES UNDISTURBED SAMPLE
- INDICATES DISTURBED SAMPLE
- INDICATES SAMPLING ATTEMPT WITH NO RECOVERY
- INDICATES LENGTH OF CORING RUN

NOTE: DEFINITIONS OF ANY ADDITIONAL DATA REGARDING SAMPLES ARE ENTERED ON THE FIRST LOG ON WHICH THE DATA APPEAR.

UNIFIED SOIL CLASSIFICATION SYSTEM

TEST PIT No. 4 DEPTH 2.0-5.0 FEET GREY CLAY WITH BROWN SILT AND SILTY SAND.

MOISTURE CONTENT IN PER CENT

ZERO AIR VOIDS CURVES

DRY DENSITY IN LBS. / CU. FT.

- SPECIFIC GRAVITY = 2.70

SPECIFIC GRAVITY = 2.60

CHECKED BY:

COPY TO EO.

DANES & MOORE

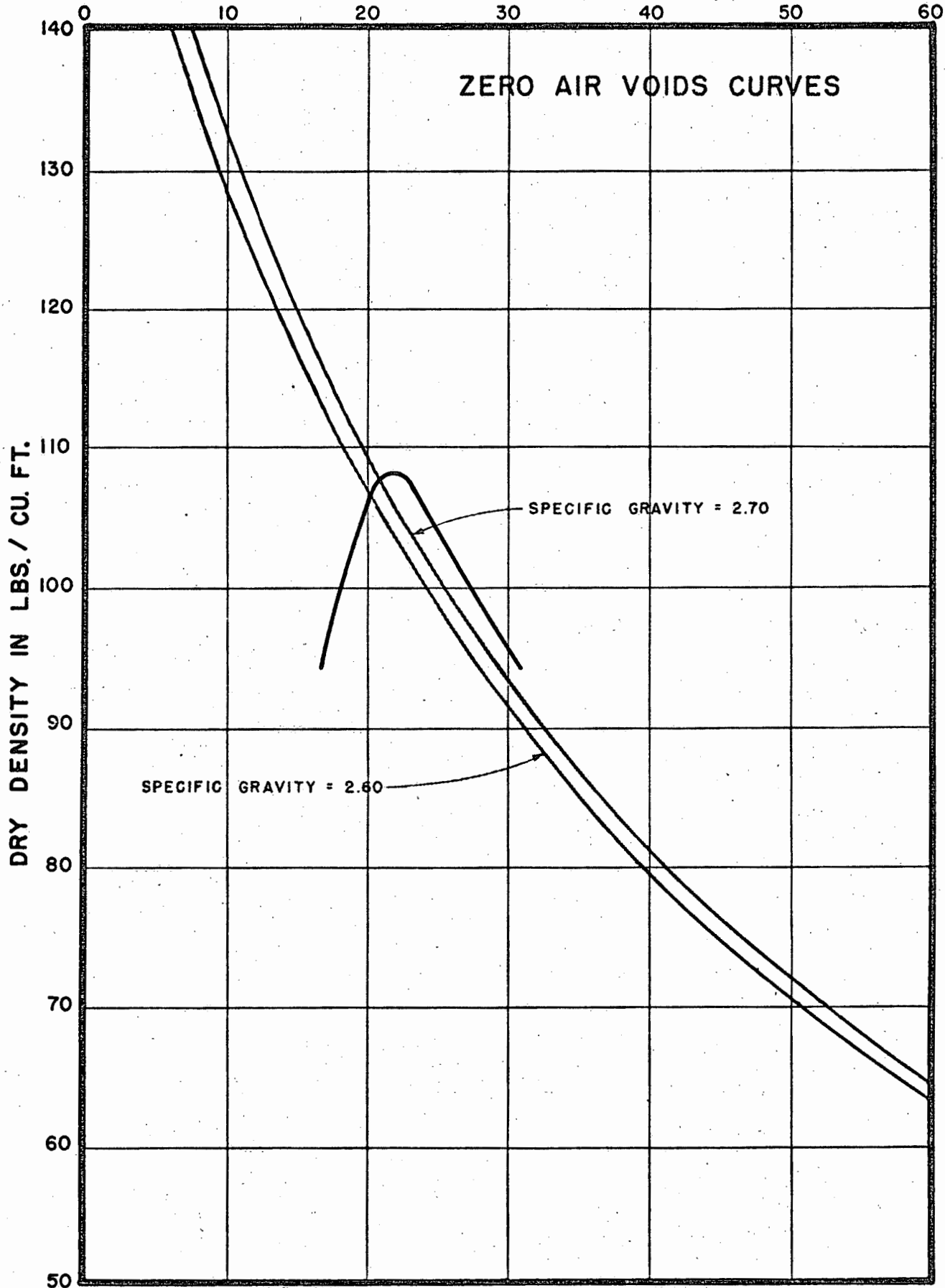
PLATE

A-3

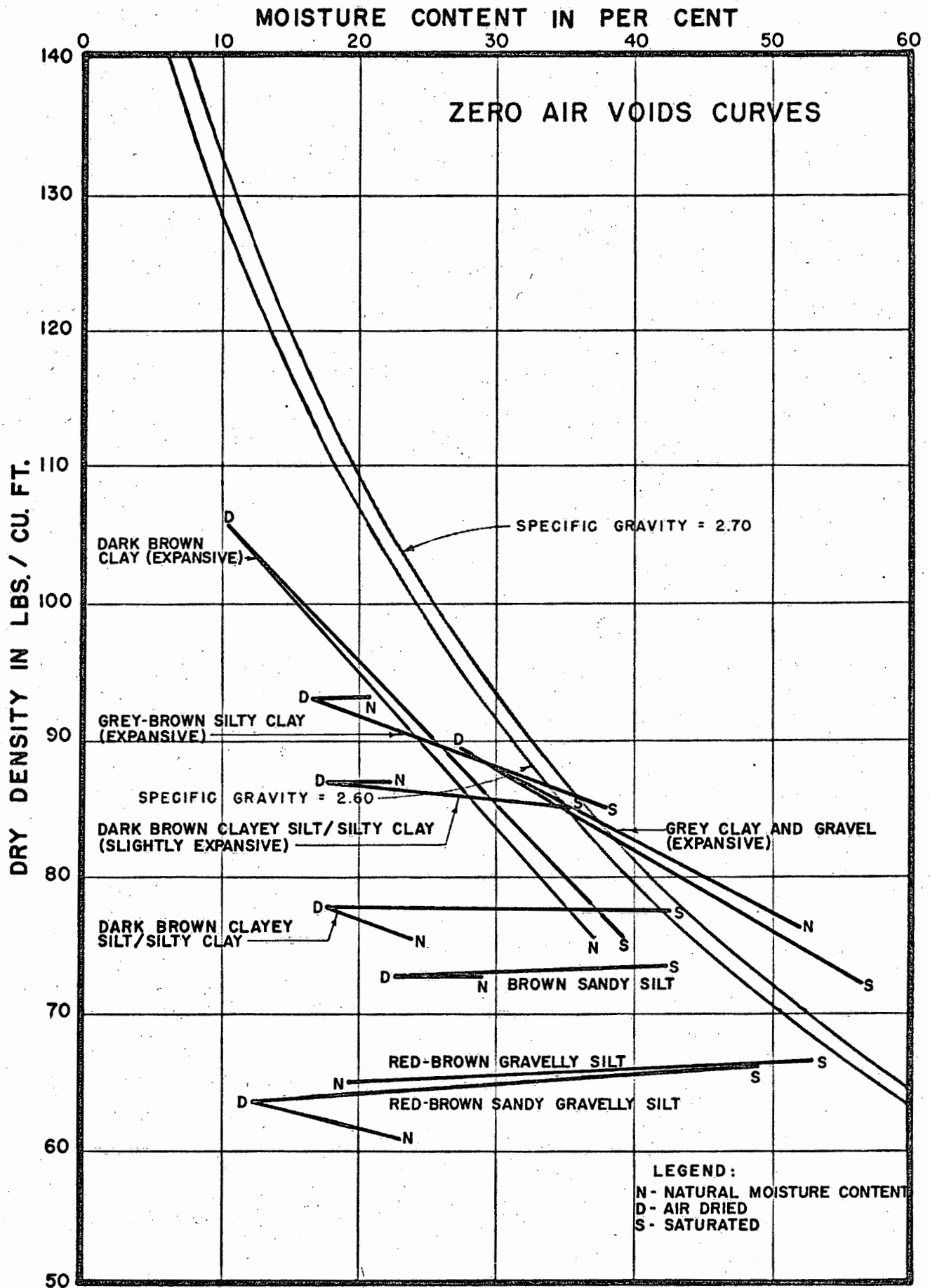
COMPACTION TEST DATA

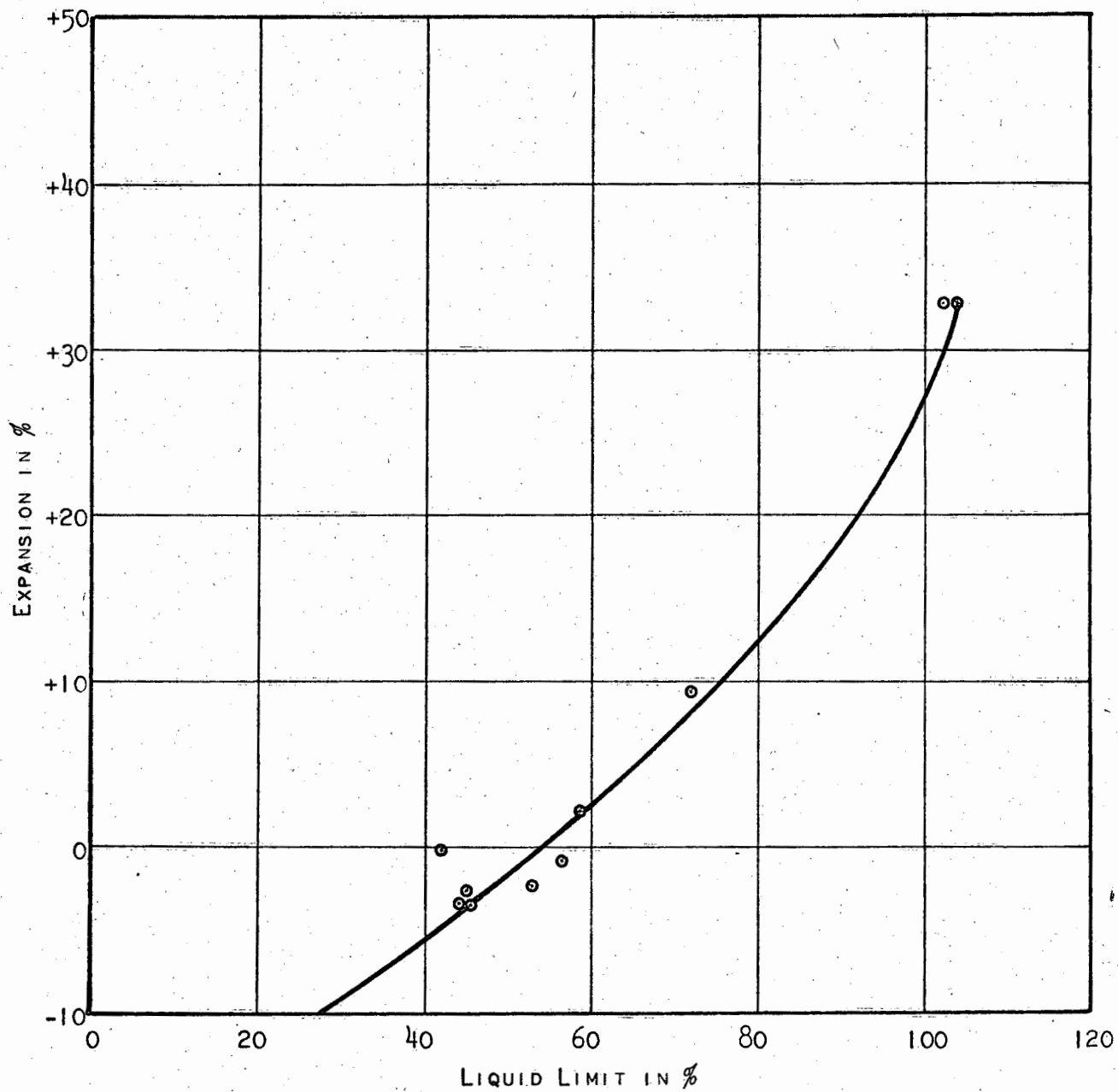
TEST PIT No. 17 DEPTH 1.0-2.0 FEET RED-BROWN SILT

MOISTURE CONTENT IN PER CENT



SOIL EXPANSION CHARACTERISTICS





SOIL EXPANSION Vs LIQUID LIMIT

REVISIONS
BY _____ DATE _____

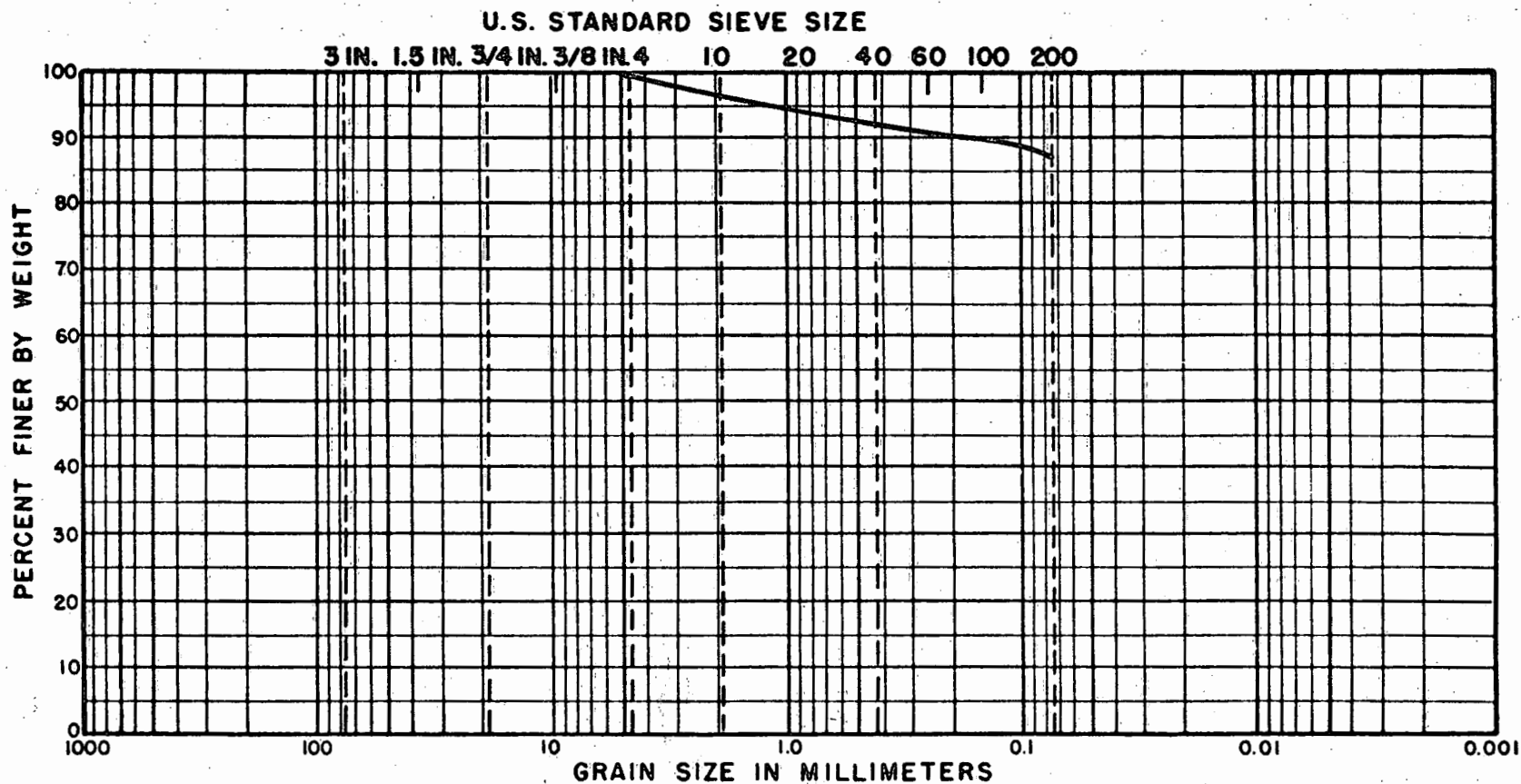
FILE 9549.col

DATE 6.26.72

CHECKED BY _____

FILE 9547-001
 BY MM DATE 6-25-72
 CHECKED BY _____ DATE _____

REVISIONS
 BY _____ DATE _____
 BY _____ DATE _____
 PLATE _____ OF _____



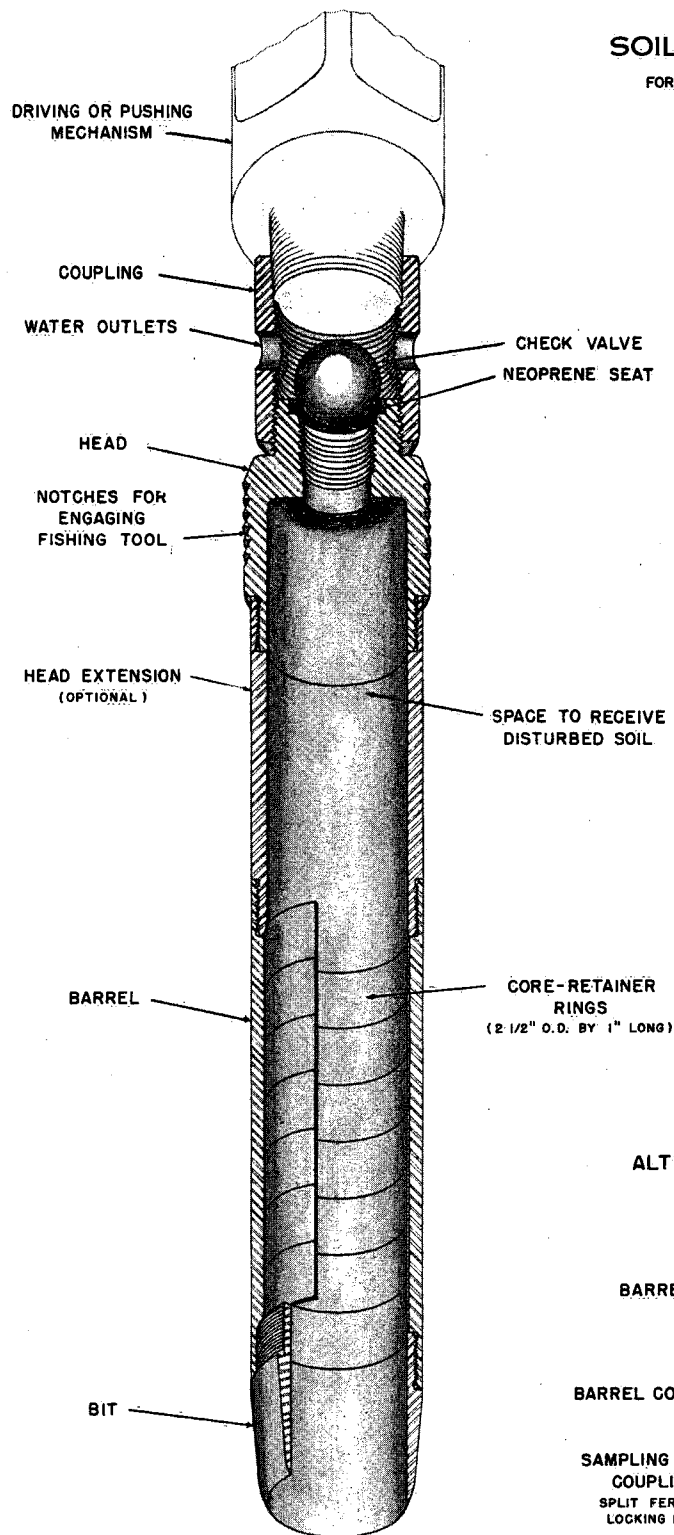
COBBLES	GRAVEL		SAND			SILT OR CLAY
	COARSE	FINE	COARSE	MEDIUM	FINE	

BORING 21	DEPTH	CLASSIFICATION	NAT. WC	LL	PL	PI	
SAMPLE 1	1.5 FEET	RED-BROWN SANDY SILT	20.1				

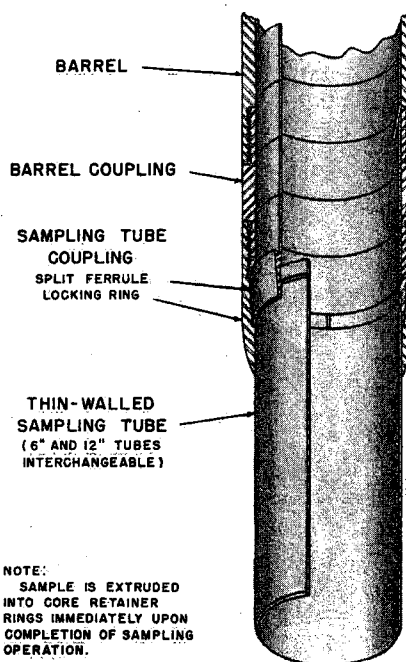
GRADATION CURVE

SOIL SAMPLER TYPE D

FOR SOILS EASY TO RETAIN IN SAMPLER



ALTERNATE ATTACHMENTS

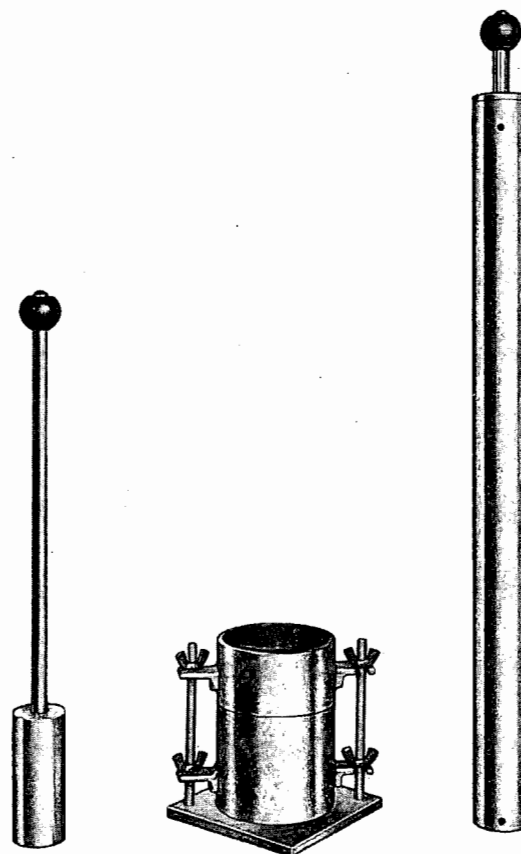


NOTE:
SAMPLE IS EXTRUDED
INTO CORE RETAINER
RINGS IMMEDIATELY UPON
COMPLETION OF SAMPLING
OPERATION.

METHOD OF PERFORMING COMPACTION TESTS
(STANDARD AND MODIFIED A.A.S.H.O. METHODS)

IT HAS BEEN ESTABLISHED THAT WHEN COMPACTING EFFORT IS HELD CONSTANT, THE DENSITY OF A ROLLED EARTH FILL INCREASES WITH ADDED MOISTURE UNTIL A MAXIMUM DRY DENSITY IS OBTAINED AT A MOISTURE CONTENT TERMED THE "OPTIMUM MOISTURE CONTENT," AFTER WHICH THE DRY DENSITY DECREASES. THE COMPACTION CURVE SHOWING THE RELATIONSHIP BETWEEN DENSITY AND MOISTURE CONTENT FOR A SPECIFIC COMPACTING EFFORT IS DETERMINED BY EXPERIMENTAL METHODS. TWO COMMONLY USED METHODS ARE DESCRIBED IN THE FOLLOWING PARAGRAPHS.

FOR THE "STANDARD A.A.S.H.O." (A.S.T.M. D698-58T & A.A.S.H.O. T99-57) METHOD OF COMPACTION A PORTION OF THE SOIL SAMPLE PASSING THE NO. 4 SIEVE IS COMPACTED AT A SPECIFIC MOISTURE CONTENT IN THREE EQUAL LAYERS IN A STANDARD COMPACTION CYLINDER HAVING A VOLUME OF 1/30 CUBIC FOOT, USING TWENTY-FIVE 12-INCH BLOWS OF A STANDARD 5-1/2 POUND RAMMER TO COMPACT EACH LAYER.



SOME APPARATUS FOR PERFORMING COMPACTION TESTS
Shows, from left to right, 5-1/2 pound rammer (sleeve controlling 12" height of drop removed), 1/30 cubic-foot cylinder with removable collar and base plate, and 10 pound rammer within sleeve.

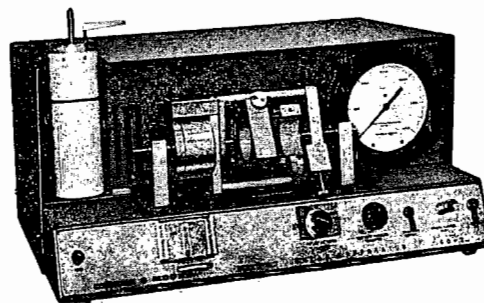
IN THE "MODIFIED A.A.S.H.O." (A.S.T.M. D-1557-58T & A.A.S.H.O. T 180-57) METHOD OF COMPACTION A PORTION OF THE SOIL SAMPLE PASSING THE NO. 4 SIEVE IS COMPACTED AT A SPECIFIC MOISTURE CONTENT IN FIVE EQUAL LAYERS IN A STANDARD COMPACTION CYLINDER HAVING A VOLUME OF 1/30 CUBIC FOOT, USING TWENTY-FIVE 18-INCH BLOWS OF A 10-POUND RAMMER TO COMPACT EACH LAYER. SEVERAL VARIATIONS OF THESE COMPACTION TESTING METHODS ARE OFTEN USED AND THESE ARE DESCRIBED IN A.A.S.H.O. & A.S.T.M. SPECIFICATIONS.

FOR BOTH METHODS, THE WET DENSITY OF THE COMPACTED SAMPLE IS DETERMINED BY WEIGHING THE KNOWN VOLUME OF SOIL; THE MOISTURE CONTENT, BY MEASURING THE LOSS OF WEIGHT OF A PORTION OF THE SAMPLE WHEN OVEN DRIED; AND THE DRY DENSITY, BY COMPUTING IT FROM THE WET DENSITY AND MOISTURE CONTENT. A SERIES OF SUCH COMPACTIONS IS PERFORMED AT INCREASING MOISTURE CONTENTS UNTIL A SUFFICIENT NUMBER OF POINTS DEFINING THE MOISTURE-DENSITY RELATIONSHIP HAVE BEEN OBTAINED TO PERMIT THE PLOTTING OF THE COMPACTION CURVE. THE MAXIMUM DRY DENSITY AND OPTIMUM MOISTURE CONTENT FOR THE PARTICULAR COMPACTING EFFORT ARE DETERMINED FROM THE COMPACTION CURVE.

EXHIBIT A-3

METHOD OF PERFORMING DIRECT SHEAR AND FRICTION TESTS

DIRECT SHEAR TESTS ARE PERFORMED TO DETERMINE THE SHEARING STRENGTHS OF SOILS. FRICTION TESTS ARE PERFORMED TO DETERMINE THE FRICTIONAL RESISTANCES BETWEEN SOILS AND VARIOUS OTHER MATERIALS SUCH AS WOOD, STEEL, OR CONCRETE. THE TESTS ARE PERFORMED IN THE LABORATORY TO SIMULATE ANTICIPATED FIELD CONDITIONS.



**DIRECT SHEAR TESTING
& RECORDING APPARATUS**

EACH SAMPLE IS TESTED WITHIN THREE BRASS RINGS, TWO AND ONE-HALF INCHES IN DIAMETER AND ONE INCH IN LENGTH. UNDISTURBED SAMPLES OF IN-PLACE SOILS ARE TESTED IN RINGS TAKEN FROM THE SAMPLING DEVICE IN WHICH THE SAMPLES WERE OBTAINED. LOOSE SAMPLES OF SOILS TO BE USED IN CONSTRUCTING EARTH FILLS ARE COMPACTED IN RINGS TO PREDETERMINED CONDITIONS AND TESTED.

DIRECT SHEAR TESTS

A THREE-INCH LENGTH OF THE SAMPLE IS TESTED IN DIRECT DOUBLE SHEAR. A CONSTANT PRESSURE, APPROPRIATE TO THE CONDITIONS OF THE PROBLEM FOR WHICH THE TEST IS BEING PERFORMED, IS APPLIED NORMAL TO THE ENDS OF THE SAMPLE THROUGH POROUS STONES. A SHEARING FAILURE OF THE SAMPLE IS CAUSED BY MOVING THE CENTER RING IN A DIRECTION PERPENDICULAR TO THE AXIS OF THE SAMPLE. TRANSVERSE MOVEMENT OF THE OUTER RINGS IS PREVENTED.

THE SHEARING FAILURE MAY BE ACCOMPLISHED BY APPLYING TO THE CENTER RING EITHER A CONSTANT RATE OF LOAD, A CONSTANT RATE OF DEFLECTION, OR INCREMENTS OF LOAD OR DEFLECTION. IN EACH CASE, THE SHEARING LOAD AND THE DEFLECTIONS IN BOTH THE AXIAL AND TRANSVERSE DIRECTIONS ARE RECORDED AND PLOTTED. THE SHEARING STRENGTH OF THE SOIL IS DETERMINED FROM THE RESULTING LOAD-DEFLECTION CURVES.

FRICTION TESTS

IN ORDER TO DETERMINE THE FRICTIONAL RESISTANCE BETWEEN SOIL AND THE SURFACES OF VARIOUS MATERIALS, THE CENTER RING OF SOIL IN THE DIRECT SHEAR TEST IS REPLACED BY A DISK OF THE MATERIAL TO BE TESTED. THE TEST IS THEN PERFORMED IN THE SAME MANNER AS THE DIRECT SHEAR TEST BY FORCING THE DISK OF MATERIAL FROM THE SOIL SURFACES.